DOCUMENT RESUME

ED 148 815 SP 012 108

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TITLE The Construction and Analysis of a Test Battery Related to Volleyball Playing Capacity in Females.
PUB DATE Sep 77
NOTE 43p.; Parts of document may be marginally legible due to print quality

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS Athletics; Motor Reactions; *Performance Factors; Performance Tests; Physical Characteristics; Physical Education; *Screening Tests; *Test Construction; Test Reliability; Test Validity; *Volleyball; *Womens Athletics

ABSTRACT

The purpose of this report was to analyze a test battery constructed to describe and predict volleyball playing capacity in college and high school women. The following criteria were used for selecting a test for initial inclusion into the battery: (1) The test is related to a basic motor ability important to playing volleyball; (2) The test can be reliable administered in mass situations. Age was selected as a test variable for the purpose of creating age adjusted norms. Height and reach were selected because of their importance for volleyball players. Weight and percent of body fat were included as well as aerobic capacity. The vertical jump and triple hop were selected as measure of jumping capacity. The twenty yard dash and agility run were selected to measure distinct dimensions of speed of body movement. The basketball throw was included as a measure of arm power. After initial pilot testing, information about the reliability and stability of the tests was obtained by testing 63 high school and college age females. Results of the various stages of analysis indicate that the test battery is a valid and reliable predictor of volleyball playing capacity for females. A generalized prediction equation for classification purposes was not derived; however, the use of performance profiles of the data is a viable means of selecting, classifying, and diagnosing in a variety of situations. (JD)

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THE CONSTRUCTION AND ANALYSIS OF A TEST BATTERY RELATED TO VOLLEYBALL PLAYING CAPACITY IN FEMALES

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A Multiphase Research Study

Prepared by James G. Disch

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completed

September, 1977

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INTRODUCTION

Decision making is an important function in any process, especially competitive situations involving athletic teams. Coaches are constantly faced with decision making situations. They decide which systems to use, how to teach skills and how to train their players. Some of their most important decisions involve selection, classification and diagnosis of players.

Most of the decisions that coaches make are based on subjective judgments. (If the coach is experienced and these judgments are soundly based, then the decisions are usually valid.) However, many of these decisions could be based on quantitative information. Coaches often chart game statistics to indicate how certain players perform, but they seldom examine physical characteristics that are related to performance.

The purpose of this report was to analyze a test battery constructed to describe and predict volleyball playing capacity in females. The Japanese (International Volleyball Federation, 1975) have been using tests of this nature for years to aid in the selection of players for their teams. In the United States Shondell, (1971) developed a battery of tests to identify potentially successful volleyball players. Using these tests as a basis an eleven item test battery was developed to predict volleyball playing capacity in females. The following criteria were used for selecting a test for initial inclusion into the battery:

1) The test is related to a basic motor ability important to playing volleyball.

2) The test can be reliably administered in mass situations.

Six variables were selected along with five anthropometric measures for the college age group and four anthropometric measures for the high school sample. The test battery is presented in Table 1. Procedures for administering these tests are presented in Appendix A.

Age was selected as a test variable for the purpose of creating age adjusted norms. Height and reach were selected because of their inherent importance for volleyball players. Both were included to examine their exact relationships to volleyball playing capacity.

Table 1: Test Battery for Predicting Volleyball Playing Capacity

Anthropometric Measures	Motor Performance Measures
Age	Submaximal Step Test
Weight	Vertical Jump
Height	Triple Hop
Reach	Agility Run
Percent Body Fat	Twenty Yard Dash
	Basketball Throw

Weight and percent body fat were included to represent distinct body composition factors. When used in a predictive sense weight with body fat controlled for is a measure of lean body mass. Body fat in this battery was predicted from skinfolds. The equation was developed by Pollock, et.al. (1974). A limitation of the equation is that it is only applicable for the college age sample.

The Queen's College Step Test was used to estimate aerobic capacity (McArdle, et.al., 1973). Submaximal Heart Rate was recorded rather than converting to oxygen uptake measures.

The vertical jump and triple hop were selected as measures of jumping capacity. Purported tests of leg power these two variables were selected since one test involved a discrete action and the other involved repetitive movement.

The twenty yard dash and agility run were selected to measure two distinct dimensions of speed of body movement. The twenty yard dash was chosen to measure

sprinting speed. The agility run was selected to measure controlled speed of body movement.

The basketball throw was included as a measure of arm power. Using a modified stance the basketball throw was supposed to be related to spiking capacity.

Once the tests had been selected the appropriateness of the battery had to be determined. This involved a multi-stage process that included pilot testing; establishing reliabilities and determining measurement schedules and developing age-based performance profiles. Also the internal structure of the battery was checked and the entire battery was validated against an external criterion.

PILOT TESTING

The test battery was initially administered to a sample of 20 girls trying out for the USA Women's Team during the summer of 1974. The camp was located in Houston and was a week in length and the girls were tested early in the week. At the end of the week eight girls were selected to remain with the USA team, while the others were classified as either alternates or regional players. The selections were based on their current playing skill. They were made by the head coach plus the assistant coaches who had no knowledge of the results of the tests.

A multiple discriminent function was used to examine the relationship between the test battery and the coaches selections. Seven of the eight national players were properly classified by the test battery. Also 11 of the 12 other players were properly classified. The 90 percent prediction rate was highly encouraging considering the homogeneity of skill level and size of the sample involved.

The variables that most significantly accounted for the precision of classification were as follows: 1) Submaximal Step Test (Heart Rate), 2) Triple Hop, 3) Weight, 4) Basketball Throw, 5) Agility Run, and 6) Twenty Yard Dash. The means and standard deviations for the entire battery for the national group and for the other group are presented in Table 2.

Table 2. Means and Standard Deviations for Test Battery on Pilot Sample

Test/Group	National (n=8) (x, s.d.)	Other (n=12) (x, s.d.)
Age (months)	269.88, 17.73	256.50, 40.92
Weight (pounds)	145.13, 10.13	138.92, 12.96
Height (inches)	67.63, 1.19	67.92, 2.27
Reach (inches)	87.13, 1.46	86.92, 2.78
Percent Fat (%)	22.13, 3.90	20.95, 3.13
Submax Heart Rate (b/m)	128.50, 8.40	142.67, 11.73
Vertical Jump (inches)	18.83, 1.13	17.29, 2.44
Triple Hop (inches)	252.41, 16.24	234.39, 17.63
Agility Run (sec.)	8.68, .29	8.98, .29
Twenty Yard Dash (sec.)	3.22, .13	3.30, .16
Basketball Throw (ft.)	58.58, 6.29	54.23, 8.08

RELIABILITY AND MEASUREMENT SCHEDULES

After the initial results of the pilot testing, information about the reliability and stability of the multiple trial motor performance tests needed to be obtained. In order to do this the test battery was administered to a group of sixty-three high school and college age females in California during the summer of 1974. Five of the six motor performance variables were multiple trial tests. Due to the measurement characteristics of the Queen's College Step Test only a single administration was possible. Five trials were administered for each of the other motor performance tests with the exception of the vertical jump that was deemed stable at three trials.

Intraclass reliability estimates were calculated using Analysis of Variance (ANOVA) procedures suggested by Kroll (1967) and expanded by Baumgartner (1975). The coefficients were calculated to be as follows: Vertical Jump - .975, Triple Hop - .964, Agility Run - .914, Twenty Yard Dash - .871, and Basketball Throw - .967. The trial means were examined to determine the measurement schedule that was both stable and represented maximized mean group performance. In order to accomplish this F-ratios were calculated to test the significance of differences among trial means. A summary of the trial means for the tests is presented in Table 3.

Table 3. Trial Means for Multiple Trial Motor Performance Tests

Test/Trial	1	2	3	4	5
Vertical Jump[1]	14.52*	14.43	14.46	———	———
Triple Hop[1]	221.62	223.33	224.44	224.82	226.89
Agility Run[2]	9.64	9.37	9.26	9.23	9.21
Twenty Yard Dash[2]	3.32	3.33	3.33	3.32	3.30
Basketball Throw[3]	42.97	45.71	46.74	47.51	49.39

*Trials underlined were those found not to be significantly different (P>.05). If significant differences were determined then the trial that maximized mean group performance was selected.
1 measured in inches
2 measured in seconds
3 measured in feet

No significant differences were found among trial means for the Vertical Jump and Twenty Yard Dash. Therefore all trials were averaged to establish the criterion measure. It was determined that three trials of the Twenty Yard Dash would be adequate to establish a trend free and reliable criterion score.

A significant F-ratio was calculated for the trial means of the Agility Run. In order to establish a trend free criterion score the ANOVA procedures suggested by Disch (1975) were used. Sequential trials were tested for trend using the Scheffe' test. Trials three, four and five were found to be trend free and also were found to maximize mean group performance. Therefore they were averaged to determine the criterion score.

The same ANOVA procedures were used for examining the trial means of the Triple Hop and Basketball Throw. No series of adjacent trials was found to trend free, therefore the single trial that maximized mean group performance was selected. In both tests this was the last trial.

This procedure for selection of a criterion score serves several purposes. First of all it locates successive trials that are similar and reflect peak

performance. Secondly, it maximizes the reliability of this series of tests. Thirdly, it identifies warm-up or learning trials as well as fatigue.

To further examine the reliability and measurement properties of the multiple trial tests additional samples were examined. Since reliability estimates are influenced by sample size and since this test battery was designed for use in groups of twenty to one hundred players the samples were analyzed separately. This was deemed a more valid procedure for the data in question.

In addition to the California group, samples were tested in Chicago (n=73), Houston (n=57), and Los Angeles - Miami (n=112). The subjects were participants in various volleyball camps and the testing was conducted in each case by a member of the USA Coaching staff that had been trained in Houston during the pilot testing. The intraclass reliabilities were estimated for the multiple trial tests in each of the samples. These coefficients along with the ranges of the values are presented in Table 4.

Table 4. Intraclass Reliabilities for Multiple Trial Motor Performance Tests

Test/Sample	California	Chicago	Houston	Los Angeles Miami	Range
Vertical Jump	.975	.986	.981	.967	.020
Triple Hop	.964	.957	.966	.969	.013
Agility Run	.914	.917	.947	.949	.036
Twenty Yard Dash	.871	.846	.872	.935	.090
Basketball Throw	.967	.945	.853	.950	.023

The stability of these coefficients calculated across samples was quite good. The reliability estimates for the Twenty Yard Dash were most variable (.846 to .935), but this represented a spread of only .090. The other tests exhibited less variability. The values of the reliability estimates were above .900 in every case with the exception of three samples on the Twenty Yard Dash. A probable

explanation for the lower reliabilites for the Twenty Yard Dash was the lack of variability between subjects. Still the values obtained were highly acceptable (.846 - .935).

The measurement schedules were also found to be consistent across samples. Therefore, the following schedule is suggested for establishing criterion scores:

Vertical Jump: average all trials

Triple Hop: use last trial

Agility Run: average last three trials

Twenty Yard Dash: average all trials

Basketball Throw: use last trial

For practical purposes this means that only the trials that are averaged or selected need to be measured. The others are considered simply warm-up. Also, for practical purposes the best trial for an individual can be used for the triple hop and basketball throw. This means that one player's first jump might be used while another player's third jump was counted. This would necessitate measuring all trials, or at least marking them. On the other hand, it would give an upper bound estimate of the individual's capacity. Although this is not the soundest procedure from a measurement standpoint, from a functional view it has merit.

AGE GROUP NORMS

With the measurement properties of the test battery established, the next step was to create descriptive profiles for players of various ages. A total sample of 331 cases was used for this phase of the analysis. This included members of the USA women's team during the spring of 1975.

The statistical characteristics of the distributions of the ten (excluding age) variables are presented in Table 5. The maximum and minimum scores are also included.

The data was then stratified into age group classifications. Subjects younger than 216 months (18 years) were grouped in Category I: High School and younger. Subjects greater than or equal to 216 months were placed in Category II: College and older. A total of 172 subjects were included in Category I, whereas 159 subjects were placed in Category II.

Percent fat was not extimated for the high school group since adequate prediction equations were not available. Mean differences were detected between categories on all the remaining tests. In each instance the difference was in the direction of the college sample. No tests of significance were calculated since this was not a substantive question for this study.

The variability for the test across groups was stable. This indicates that as the players get older the performance level rises, but the dispersion stays relatively constant. Examination of the skewness and kurtosis measures for the various distributions indicated that, while the variability remained the same the shape of the distributions was changing. This finding might limit the predictive validity of this battery across a period of years.

Percentile ranks for the subjects by categories were then calculated on the remaining tests. Profile charts for these percentile ranks were developed and these charts are presented in Table 6 and 7.

Table 5

VOLLEYBALL PERFORMANCE PROFILE

DESCRIPTIVE DATA SUMMARY

Statistic (level)		Weight	Height	Reach	Percent Body Fat	Sub Max Heart Rate	Vertical Jump	Triple Hop	Agility Run	Twenty Yard Dash	Basketball Throw
Mean	High School	131.79	65.75	84.69	X	153.31	14.23	214.50	9.69	3.40	47.43
	College	140.01	67.45	86.80	18.08	141.52	16.02	235.79	9.24	3.38	54.96
Standard Deviation	High School	19.75	2.96	3.85	X	19.76	2.41	24.28	.70	.24	9.14
	College	16.76	2.93	3.98	5.85	17.91	2.95	24.60	.69	.26	8.66
Skewness	High School	.687	-.209	.291	X	.257	.508	.118	.588	.923	.162
	College	.406	.059	-.062	1.582	-.059	-.009	.086	.464	.526	.100
Kurtosis	High School	1.072	1.407	.340	X	1.146	.516	-.242	.664	3.03	.030
	College	.514	.253	.174	2.359	.623	-.172	.035	-.427	.023	.880
Maximum	High School	204	74.0	96.0	X	224.0	22.0	273.0	12.23	4.63	70.83
	College	200	77.0	98.5	40.68	192	24.0	307.0	10.97	4.10	82.27
Minimum	High School	88	53.0	74.0	X	104	7.5	144.2	8.00	2.87	18.00
	College	95	60.0	76.0	11.18	80	10.0	169.2	7.90	2.83	26.33

These charts can be used to serve several valuable functions. They are primarily suited for comparative purposes. First of all, team averages can be compared to other teams. Also, starters on a team can be compared to non-starters. Then individuals could be compared to any of the averages previously mentioned. This could serve as a valuable diagnostic tool. Another primary use of this information could be to compare a player to himself at various points in time. For example, a player could be tested at the beginning of each competitive season to measure yearly changes. Or, a player could be measured at various points during a season to examine conditioning effects or possibly fatigue. In summary these charts serve as concrete evidence for decision making by the coach.

Table 6: Category I

VOLLEYBALL PERFORMANCE PROFILE

High School Sample (N = 172)

Percentiles	Weight	Height	Reach	Sub Max Heart Rate	Vertical Jump	Triple Hop	Agility Run	Twenty Yard Dash	Basketball Throw	Percentiles
99+	204	74.0	96.0	104	22.0	273.0	8.00	2.87	70.83	99+
95	169	71.0	91.0	120	18.5	257.0	8.67	3.04	64.50	95
90	159	70.0	90.0	128	17.8	247.0	8.90	3.12	60.00	90
85	150	69.0	88.0	132	16.5	241.4	8.97	3.17	57.00	85
80	146	68.0	X	140	16.0	235.4	9.10	3.20	55.00	80
75	143	67.5	87.0	142	15.7	232.0	9.17	3.23	52.83	75
70	141	67.0	86.5	146	15.3	225.6	9.27	3.26	51.49	70
65	136	66.5	86.0	X	15.0	221.0	9.37	3.28	50.50	65
60	134	66.0	85.5	148	14.5	219.0	9.40	3.32	49.00	60
55	131	X	85.0	152	14.2	216.6	9.57	3.34	48.42	55
50	130	65.5	84.5	154	14.0	212.2	9.63	3.37	47.17	50
45	127	X	84.0	156	13.7	209.8	9.70	3.42	46.00	45
40	125	65.0	83.5	158	13.5	206.4	9.80	3.46	44.54	40
35	124	X	83.0	160	13.3	203.0	9.87	3.47	43.50	35
30	121	64.0	82.0	162	13.0	200.4	10.03	3.50	42.00	30
25	120	X	X	164	12.5	197.4	10.10	3.53	40.83	25
20	117	62.5	81.5	168	12.3	195.0	10.20	3.57	39.17	20
15	112	X	81.0	170	12.0	191.0	10.33	3.60	37.83	15
10	109	62.0	80.0	176	11.5	188.4	10.70	3.67	36.42	10
5	104	61.0	79.0	184	11.0	177.0	10.97	3.80	33.50	5

Note: An "X" was used if no distinct score was attainable.

Table 7. Category II

VOLLEYBALL PERFORMANCE PROFILE

College Sample (N = 159)

Percentiles	Weight	Height	Reach	Percent Fat	Sub Max Heart Rate	Vertical Jump	Triple Hop	Agility Run	Twenty Yard Dash	Basketball Throw	Percentiles
99+	200	77.0	96.5	11.16	80	24.0	307.0	7.90	2.83	82.27	99+
95	165	72.0	93.0	12.20	100	20.5	278.0	8.27	3.00	68.54	95
90	160	71.0	91.5	12.60	116	19.8	268.0	8.40	3.07	66.82	90
85	159	70.0	90.5	13.19	120	19.0	262.0	8.50	3.12	63.96	85
80	156	69.5	90.0	13.51	124	18.5	254.0	8.60	3.16	61.19	80
75	152	69.0	89.5	13.98	X	18.0	250.0	8.75	3.17	59.44	75
70	150	X	89.0	14.41	128	17.5	247.2	8.83	3.20	58.33	70
65	145	68.5	88.5	14.61	X	17.0	244.8	8.90	3.27	57.64	65
60	142	68.0	88.0	15.13	132	16.8	241.6	8.97	3.30	56.64	60
55	138	X	87.5	15.51	136	16.5	237.0	9.10	3.33	56.08	55
50	135	67.5	87.0	16.00	140	16.0	233.0	9.17	3.37	55.04	50
45	X	67.0	86.5	16.50	X	15.8	231.0	9.30	3.40	53.85	45
40	134	X	86.0	17.50	144	15.5	299.6	9.37	3.42	52.25	40
35	133	66.0	85.0	18.16	148	15.0	226.0	9.43	3.44	51.12	35
30	130	X	84.5	18.80	150	14.7	222.9	9.48	3.50	51.00	30
25	128	65.5	84.0	20.48	152	14.0	222.2	9.67	3.53	50.06	25
20	127	65.0	83.0	21.45	156	13.5	217.0	9.87	3.60	48.73	20
15	125	64.0	82.5	22.93	158	12.7	212.2	10.03	3.67	46.62	15
10	123	63.5	81.5	25.96	160	11.5	203.0	10.30	3.73	45.79	10
5	115	62.5	80.0	31.32	168	10.5	193.0	10.50	3.83	41.19	5

Note: An "X" was used if no distinct score was attainable.

ANALYSIS OF THE INTERNAL STRUCTURE OF THE TEST BATTERY

This 11 item battery was composed of tests chosen to represent two domains related to human performance: anthropometric measures and motor ability measures. For purposes of this test battery the submaximal step test was classified with the motor performance variables. It would normally be classified with physiological measures.

In order to examine the internal structure of the entire battery the correlations among 10 tests (age excluded) were calculated. Only the college age sample (Category II) was used since the percent fat could not be validly measured in the younger sample. The correlation matrix for the 10 variables is presented in Table 8.

A correlation of .206 was needed to be statistically significant at the .01 level. Three of the six intercorrelations among the anthropometric variables were significant, whereas 12 of the 15 relationships among the motor performance measures were significant. Only three of the 24 correlations across domains were significant with the values ranging in magnitude from .218 to .221.

Canonical correlation analysis was used to examine the relationship of the anthropometric domain to the motor performance group. Four canonical correlations were calculated between pairs of vectors (canonical variates) from the two experimental domains. The canonical correlations along with their associated eigenvalues and significance tests are presented in Table 9.

Three Canonical Correlations were found to be significant ($P<.05$). The magnitudes of these correlations were found to be .575, .418, and .325, respectively. The significance of the coefficients indicate that there were three distinct patterns of covariation present across the two subbatteries of tests. Redundancy coefficients for the three variates were then calculated to examine the proportion of the variance of one battery accounted for by the other. A summary of the coefficients is presented in Table 10.

Table 8. Ten Variable Correlation Matrix*

	Weight	Height	Reach	Percent Fat	Submax Heart Rate	Vertical Jump	Triple Hop	Agility Run	Twenty Yard Dash	Basketball Throw
Weight	1.000	0.638	0.675	0.113	-0.021	-0.026	-0.023	0.094	0.076	0.202
Height	0.638	1.000	0.917	0.047	-0.044	0.149	0.218	-0.080	-0.084	0.155
Reach	0.675	0.917	1.000	-0.021	-0.020	0.065	0.221	-0.048	-0.099	0.183
Percent Fat	0.113	0.047	-0.021	1.000	-0.099	-0.122	-0.218	-0.100	-0.130	-0.197
Submax Heart Rate	0.021	-0.044	-0.020	-0.099	1.000	-0.187	-0.140	0.256	0.212	-0.083
Vertical Jump	-0.025	0.149	0.065	-0.122	-0.187	1.000	0.723	-0.693	-0.672	0.355
Triple Hop	-0.023	0.218	0.221	-0.218	-0.140	0.723	1.000	-0.622	-0.668	0.341
Agility Run	0.094	-0.080	-0.048	-0.100	0.256	-0.693	-0.662	1.000	0.795	-0.325
Twenty Yard Dash	0.076	-0.084	-0.099	-0.130	0.212	-0.672	-0.668	0.795	1.000	-0.325
Basketball Throw	0.202	0.155	0.183	-0.197	-0.083	0.355	0.341	-0.325	-0.325	1.000

* $r \geq .206$ ($p < .01$)

Table 9. Canonical Correlations, Eigen Values, and Significance Levels

Number	Eigen Value	Canonical Correlation	Chi-Square	D.F.	Significance Levels
1	0.331	0.575	112.717	24	0.0001
2	0.175	0.418	49.827	15	0.0001
3	0.106	0.325	19.668	8	0.0120

Table 10. Redundancy Coefficients for the Canonical Variates

Redundancy Coefficient	Variate 1	Variate 2	Variate 3	Total
Motor Performance on Anthropometric	.155	.021	.010	.186
Anthropometric on Motor Performance	.046	.014	.029	.089

The magnitudes of the redundancy coefficients suggest that, although three statistically significant variates were isolated, they were of little practical significance. Less than twenty percent of the total variance of the anthropometric tests was related to that of the motor performance tests. The amount of the total variance of the motor performance battery associated with the anthropometric measures was less than nine percent.

Analysis of the contribution of specific variables to the various dimensions is heuristically interesting, but it is of minimal practical value. For those that are interested Appendix B contains the canonical weights, loadings, and indices for the variables on the significant variates.

In conclusion it can be stated that the two subbatteries were related in three dimensions. The amount of this relationship, however, was low in magnitude. This justifies the inclusion of the tests in each battery as unique measures of various components within the internal structure of entire set of tests.

CRITERION RELATED VALIDITY OF THE TEST BATTERY

As a result of pilot testing it was suggested that this test battery was a valid discriminator of volleyball playing capacity. However, this finding was based on data from only 20 subjects.

In order to generalize the validity of this battery, two analyses were conducted. First of all a discriminant function was calculated for predicting level of playing ability from the test battery. Secondly, subsequent samples were analyzed in order to cross validate the previous results.

In the first phase of the validation process a discriminant analysis was conducted using the Chicago sample. The 73 subjects were classified by the coaches involved into three ability groups: high, average, and low. The tests were then used to classify the players into the appropriate groups. Analysis of the results indicated the 89 percent of the players were property classified using this battery. The classification table is presented in Table 11.

Table 11. Discriminant Function Classification Table: Chicago Sample

Selected/Predicted	High	Average	Low
High	12	1	0
Average	1	46	5
Low	0	1	7

The variables that were most discriminating were as follows:

1) Basketball Throw
2) Vertical Jump
3) Percent Fat
4) Twenty Yard Dash
5) Weight
6) Agility Run
7) Submaximal Heart Rate

In order to replicate these results, the Los Angeles - Miami sample was split into two subsamples. Stepwise Discriminant Analyses were performed on the subsamples. The Miami subsample was composed of 53 cases, whereas the Los Angeles

group was composed of 55 subjects. In the first sample 67.92 percent of the subjects were properly classified, whereas 67.27 percent were correctly predicted in the second sample. Although the level of classification was statistically significant for both groups, the percent of proper classifications was much lower than the 90 percent level of the pilot group and the 89 percent prediction level of the Chicago group. Both samples in this phase were more homogeneous in skill level than the Chicago group. This could have caused the reduced level of prediction. However, the pilot sample was the most homogeneous group and 90 percent were classified properly.

Inspection of the variables involved the classification index for the two groups indicates that no generalized equation adequately predicts across groups. In both samples only one discriminant function was significant, but the variables and their magnitude of contribution varied for the two groups. Table 12 presents the variables in the order of inclusion that composed the classification function for the two groups.

Table 12. Classification Variables and Weights for the Miami and Los Angeles Subsamples

Miami	Los Angeles
Variable (Standardized Weight)	Variable (Standardized Weight)
Twenty Yard Dash (1.163)	Twenty Yard Dash (.787)
Triple Hop (.615)	Height (-.865)
Height (-.447)	Vertical Jump (-.646)
Submaximal Step Test (.337)	Triple Hop (.774)
Vertical Jump (-.266)	Weight (.334)

Five variables were included in each function and four of the variables were the same for both samples: (1) Twenty Yard Dash, (2) Triple Hop, (3) Height, and (4) Vertical Jump. The Submaximal Step Test was included in the Miami function, whereas Weight was included in

the Los Angeles data. The order of entry of the tests and the magnitude of the weights indicate that the functions are specific to the samples involved. Since the samples were of varying ability levels, this is a logical finding.

In conclusion, the criterion related validity of the test battery was established. However, no suitable classification function was derived for general usage. The most logical procedures is to fit a profile to the specific group, team, or individual involved.

DISCUSSION OF FINDINGS

The results of the various stages of analysis indicate that the 11 item test battery is a reliable and valid predictor of volleyball playing capacity for females. A generalized prediction equation for classification purposes was not derived, however the use of performance profiles of the data is a viable means of selecting, classifying, and diagnosing in a variety of situations. Examples of specific uses of these profiles is presented in the following section.

An analysis of the pilot data is an example of the use of the test battery for selection purposes. The pilot data was collected at a try out camp for the U.S.A. Women's Team in the summer of 1974 in Houston. Of the twenty girls trying out eight were selected for the national program. Seven of the eight girls were properly classified by the test battery. It was noted by the testors that the lone girl that was misclassified did not give maximum effort during the testing sessions.

Table 13 presents a profile plot of the National girls as opposed to the Regional girls. There was a clear spread between the groups' means on all of the performance tests. The differences on the anthropometric tests were not consistent in magnitude or direction.

Heart rate from the step test, the triple hop, and the basketball throw were the variables that best discriminated between groups in this specific case. The ability to select seven of the eight girls chosen from such a highly skilled group indicates that the battery may be used in a variety of situations.

The test battery was used for classification purposes during the past two summer (1976, 1977) at Purdue University. Junior high school and high school girls participated in a week long volleyball camp. On the first night of camp all of the girls were given the battery of tests along with some skill

Table 13: National Versus Regional Selections

VOLLEYBALL PERFORMANCE PROFILE

College Sample (N = 159)

Percentiles	Weight	Height	Reach	Percent Fat	Sub Max Heart Rate	Vertical Jump	Triple Hop	Agility Run	Twenty Yard Dash	Basketball Throw	Percentiles
99+	200	77.0	98.5	11.18	80	24.0	307.0	7.90	2.83	82.27	99+
95	165	72.0	93.0	12.20	100	20.5	278.0	8.27	3.00	68.54	95
90	160	71.0	91.5	12.60	116	19.8	268.0	8.40	3.07	66.82	90
85	159	70.0	90.5	13.19	120	19.0	262.0	8.50	3.12	63.96	85
80	156	69.5	90.0	13.51	124	18.5	254.0	8.60	3.16	61.19	80
75	152	69.0	89.5	13.98	X	18.0	250.0	8.75	3.17	59.44	75
70	150	X	89.0	14.41	128	17.5	247.2	8.83	3.20	58.33	70
65	145	68.5	88.5	14.61	X	17.0	244.8	8.90	3.27	57.64	65
60	142	68.0	88.0	15.13	132	16.8	241.6	8.97	3.30	56.64	60
55	138	X	87.5	15.51	136	16.5	237.0	9.10	3.33	56.08	55
50	135	67.5	87.0	16.00	140	16.0	233.0	9.17	3.37	55.04	50
45	X	67.0	86.5	16.50	X	15.8	231.0	9.30	3.40	53.85	45
40	134	X	86.0	17.50	144	15.5	299.6	9.37	3.42	52.25	40
35	133	66.0	85.0	18.18	148	15.0	226.0	9.43	3.44	51.12	35
30	130	X	84.5	18.80	150	14.7	222.9	9.48	3.50	51.00	30
25	128	65.5	84.0	20.49	152	14.0	222.2	9.67	3.53	50.06	25
20	127	65.0	83.0	21.45	156	13.5	217.0	9.87	3.60	48.73	20
15	125	64.0	82.5	22.93	158	12.7	212.2	10.03	3.67	46.62	15
10	123	63.5	81.5	25.96	160	11.5	203.0	10.30	3.73	45.79	10
5	115	62.5	80.0	31.32	168	10.5	193.0	10.50	3.83	41.19	5

Key: ——— National group
. . . . Regional group

tests. The results of these tests were used to classify the girls into homogeneous groups.

Although no statistical analyses were conducted on the Purdue data, the camp director and staff felt the grouping did facilitate teaching. Also, a large percentage of the girls selected as "all-stars" at the end of the week had performed well on the performance tests.

A third example deals with the diagnostic uses of the battery. During the fall of 1974 the Rice University Women's Volleyball Team was administered the battery of tests. Table 14 presents a profile of the team's mean performance levels plus the profiles of two players. Only eight of the eleven tests were administered to the players. The team profile was in the moderate range on height and reach (60^{th} and 55^{th} percentile, respectively), but it did not exceed the 20^{th} percentile on any of the other measures.

Player #1 was a highly skilled player and ranked above the 50^{th} percentile on all the performance tests except the vertical jump. In comparison to the team she excelled in the vertical jump, but by comparing her to a general population it was evident that she needed work on the vertical jump.

Player #2, on the other hand, profiled the team quite closely except that she had an inordinately long reach for her height. She was an effective blocker simply because she had long arms. By pointing out that she was only in the 10^{th} percentile on the vertical jump the need for her to improve her leg power was dramatized.

These are just selected examples of the various uses of this type of performance data. It is hoped that test batteries similar to this one can be developed for use in other sports.

Table 14: Rice Women's Team, 1974

VOLLEYBALL PERFORMANCE PROFILE *

College Sample (N = 159)

Percentiles	Weight	Height	Reach	Percent Fat	Sub Max Heart Rate	Vertical Jump	Triple Hop	Agility Run	Twenty Yard Dash	Basketball Throw	Percentiles
99+	200	77.0	98.5	11.18	80	24.0	307.0	7.90	2.83	82.27	99+
95	165	72.0	93.0	12.28	100	20.5	278.0	8.27	3.00	68.54	95
90	160	71.0	91.5	12.60	116	19.8	268.0	8.40	3.07	66.82	90
85	159	70.0	90.5	13.19	120	19.0	262.0	8.50	3.12	63.96	85
80	156	69.5	90.0	13.51	124	18.5	254.0	8.60	3.16	61.19	80
75	152	69.0	89.5	13.98	X	18.0	250.0	8.75	3.17	59.44	75
70	150	X	89.0	14.41	128	17.5	247.2	8.83	3.20	58.33	70
65	145	68.5	88.5	14.61	X	17.0	244.8	8.90	3.27	57.64	65
60	142	68.0	88.0	15.13	132	16.8	241.6	8.97	3.30	56.64	60
55	138	X	87.5	15.51	136	16.5	237.0	9.10	3.33	56.08	55
50	135	67.5	87.0	16.00	140	16.0	233.0	9.17	3.37	55.04	50
45	X	67.0	86.5	16.50	X	15.8	231.0	9.30	3.40	53.85	45
40	134	X	86.0	17.50	144	15.5	229.6	9.37	3.42	52.25	40
35	133	66.0	85.0	18.18	148	15.0	226.0	9.43	3.44	51.12	35
30	130	X	84.5	18.80	150	14.7	222.9	9.48	3.50	51.00	30
25	128	65.5	84.0	20.48	152	14.0	222.2	9.67	3.53	50.06	25
20	127	65.0	83.0	21.45	156	13.5	217.0	9.87	3.60	48.73	20
15	125	64.0	82.5	22.93	158	12.7	212.2	10.03	3.67	46.62	15
10	123	63.5	81.5	25.96	160	11.5	203.0	10.30	3.73	45.79	10
5	115	62.5	80.0	31.32	168	10.5	193.0	10.50	3.83	41.19	5

Key:

Team Profile: _____
Player #1: . . . . .
Player #2: + + + + +

* No Data Available for Weight and Heart Rate

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APPENDIX

APPENDIX A

VOLLEYBALL PERFORMANCE TEST BATTERY*

Objective: The primary objective of this battery of tests is to measure basic components of human motor performance important to volleyball. The results of this test battery may be used to develop player profiles and/or discriminate between players performance capacities.

Test Battery:

1) Vertical Jump - to measure leg power
2) Triple Hop - to measure leg power and coordination
3) Agility Run - to measure controlled speed
4) 20-Yard Dash - to measure sprinting speed
5) Basketball Throw - to measure arm power
6) Queen's College Step Test - to measure aerobic capacity

Anthropometric Measures:

1) Age - to nearest month
2) Weight - to nearest pound
3) Height - to nearest inch
4) Reach - to nearest inch
5) Percent Body Fat - using technique developed by Pollock, et. al. (1974)

PROCEDURES

Order of Administration:

1) Queen's College Step Test - (administrator and 2-3 recorders).

   a) Equipment - cassette tape recorder
      - stepping tape
      - bleacher height benches.
   b) Instructions - on the tape: be sure you are familiar with it and know when to stop it!

2) Skin Folds - (may be collected at any time during the testing process - important that same person takes all folds - administrator and recorder).

   a) Equipment - skin fold calipers.
   b) Instructions - subjects stand in stride position, weight supported on left foot. Take first fold at mid-thigh position of right leg. Take second fold at suprailiac crest. Three independent folds should be taken at each sight and the average recorded. This can then be converted to % body fat from the material presented in Pollock, et. al. (1974)

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* This test battery was developed during the summer of 1974 at the try-out for the USA Women's Volleyball Team in Houston, Texas. Those who helped develop this test battery are as follows: James Disch, Peter Field, Dixie Grimmett, Andrew Jackson and Taras Liskevych.

3) Vertical Jump - (administrator and recorder).

a) Equipment - strip of tape calibrated in inches (adjust to characteristics of subjects involved; should run from 5' to 10' at least).
b) Instructions - first measure height with subject standing with back to the wall; then, measure reach with dominant arm only in complete extension above head (be sure to instruct subjects to laterally flex trunk to gain complete extension); and finally, administer 3 trials of jump. Subjects should stand facing parallel to the wall with dominant arm closest to wall. They should be a comfortable distance from the wall and tape so that their jump is not restricted; they must jump from a standing position using a 2-foot take-off. They are allowed no approach, but may rock on their heels. They should pause several seconds between trials to avoid repeat jumps. The trials should be administered consecutively and recorded to the nearest inch. (Hint - helpful if recorder stands on chair).

4) Triple Hop - (administrator and recorder).

a) Equipment - tape calibrated in inches.
b) Instructions - subjects should be tested in groups of 4-8, so there is a short rest period between each jump. The subject performs 5 trials of this test. The test consists of 3 successive 2-foot hops in rhythmical fashion (standing broad jump technique). If the subject falls backwards or uses one foot take-offs, additional trials should be administered until 5 good trials have been completed. Score is recorded to nearest inch of each trial.

5) Agility Run - (administrator, recorder, 1-2 timers).

a) Equipment - stop watches.
b) Course - 15' course marked with foot long strips of tape on each side.
c) Instructions - test can be run in pairs in which case 2 stop watches are needed. 4-8 people in a group. Subject stands in a low defensive position with feet parallel to the line of the course. On "go", the subject traverses the course 6 times as rapidly as possible. Each time she comes to the tape she must touch the tape with her feet and the floor beyond with her hand. The timers should be instructed to start on the subject's first movement, not on the "go" command. Five trials of this test are administered. Time is recorded to the nearest .10 second.

6) Twenty-Yard Dash - (administrator, recorder, 1-3 timers).

a) Equipment - Stop watches.
b) Instructions - subjects may run in as large a group as feasible. Groups of 2 or 3 are probably best. If 4-8 people are tested at once and run in heats, sufficient rest is obtained. Subjects use a standing 2-foot start. The commands are - "Ready", "Go". The watches should not begin until the subject moves and time is recorded to the nearest .10 second. Three trials are administered.

7) Basketball Throw - (administrator, recorder, shagger).

a) Equipment - 2 basketballs
- 100' long cloth tape measure (or substitute)
- 5 masking tape markers (#1-5).

b) Instructions - five successive throws are awarded and marked with markers (in order). The throws must be made with both feet parallel to restraining line. The subject may not take a step to throw, but may follow through by stepping over the line after the throw. After the throws are completed they are all measured to the nearest inch.

Comments

Test should be administered when girls are in a rested state. Maximum effort is extremely important.

Clipboards and pencils should be supplied to each station.

Timers, administrators, recorders and shaggers should be well trained prior to testing.

APPENDIX B

CANONICAL WEIGHTS, LOADINGS, AND INDICES

Variables (Variate)	Canonical Weights (1)	(2)	(3)	Canonical Loadings (1)	(2)	(3)	Canonical Indices (1)	(2)	(3)
Weight	-.381	.588	1.139	.295	-.051	.586	-.122	.066	.188
Height	-.878	1.606	-1.509	-.345	-.281	.244	-.011	.124	-.292
Reach	.797	-2.468	.606	.285	-.599	-.006	.023	.120	.212
Percent Fat	.954	.024	-.010	.853	.218	.035	.006	-.208	-.143
Submax Heart Rate	-.046	-.077	-.052	.185	.111	.215	.081	.044	-.026
Vertical Jump	-.591	1.189	-.433	-.321	.142	-.658	.064	.053	.022
Triple Hop	-.724	-1.134	-.487	.372	.513	-.673	-.205	-.240	.026
Agility Run	-.458	-.406	.420	.175	.104	.614	-.044	.025	.034
Twenty Yard Dash	-.928	.693	-.230	-.564	.365	.477	-.088	.051	.022
Basketball Throw	-.441	-.161	.715	-.451	.225	.329	-.110	-.206	.145